Obtaining Cue Rate Estimates for Some Mysticete Species using Existing Data

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LONG-TERM GOALS

The long-term goals of this research effort are to improve the Navy's passive underwater acoustic monitoring of marine mammal populations. A major focus in this project is on further enhancing the ability to estimate animal density (animals per unit area per unit time) obtained from raw detections of calls in underwater acoustic recordings. The efforts in this program also will support the Master's Thesis research of Roanne Manzano-Roth at the Naval Postgraduate School in Monterey.

OBJECTIVES

An emerging area of study in the field of marine mammal passive acoustics is the estimation of animal population densities from detections in passive acoustic data. In order to calculate animal density from passive acoustics, one must know the species-specific average cue rate, which is the average number of calls produced per animal per time. The cue rate can vary significantly by location and season, in addition to other factors. The objective of this proposed effort is to estimate average cue rates for several species of endangered mysticete whales on and near U.S. Navy ranges, using existing recordings from both the SCORE and PMRF hydrophone networks. One primary focus is to obtain cue rates for humpback whales (Megaptera novaeangliae) off the California coast and on the PMRF range. To our knowledge, no humpback whale cue rates have been calculated for these populations. Once a cue rate is estimated for the populations of humpback whales off the California coast, density estimates can be readily calculated using previously published results of environmentally calibrated call densities. Animal density estimates are of great interest to NAVFAC monitoring efforts. The PMRF range off the coast of Hawaii provides an opportunity to estimate cue rates for humpback whales on breeding grounds, in addition to average cue rates for other species of mysticete whales. Cue rates of several other species of baleen whales off the California coast, including fin whales (Balaenoptera physalus), also can be estimated from existing data sets (e.g., the MNT/FET data set collected in 1999 by the ADS program) and so warrants additional study.

APPROACH

Because of their extensive spatial coverage in areas of direct relevance to the U.S. Navy, datasets from the SCORE and PMRF ranges provide a unique opportunity for passive acoustic monitoring.

Extensive recordings from the PMRF range are already in-house, provided by Steve Martin at SSC Pacific. SCORE range data is obtainable through David Morreti at NUWC.

We propose to use these datasets and others readily available to estimate cetacean cue rates for several species. In the near term, the SCORE range datasets can be used to track humpback whales, providing cue rates for transiting humpback whales off the coast of California. Because significant work has already been conducted on developing a viable humpback detection algorithm (Helble et al, 2012), and calculating the site specific probability of detection at certain locations off the coast of California (Helble et al, 2013a), obtaining a cue rate for the region will immediately yield humpback whale density estimates for transiting humpback whales in the southern California region (Helble et al, 2013c).

The SCORE range also provides a unique opportunity to validate methods for determining the site-specific probability of detection, which is an important parameter for density estimation (Eq. 1). The probability of detection at the SCORE range can be estimated using two methods. The first, outlined in Helble et al, 2013a, uses physics-based, full-wave-field, acoustic modeling techniques. The second method uses localization techniques to estimate the probability of detection. Humpback whale calls in the southern California region provide an ideal signal for validating the site specific probability of detection using localization techniques because the relatively low animal densities can provide unambiguous locations using the overlapping and extensive spatial coverage of the SCORE range hydrophones. Comparison of the two methods will provide insight into the effectiveness of each method. The acoustic modeling portion of the comparison study is already funded by the LMR proposal Improving the Navy's Automated Methods for Passive Underwater Acoustic Monitoring of Marine Mammals (PI Tyler Helble), and so a comparison of the two methods can be highly leveraged of that effort.

Data from the PMRF range off the coast of Kauai provide the opportunity to apply the same techniques described in the previous paragraph for the study of humpback whales on winter breeding grounds. We hypothesize that the cue rates will vary considerably from those calculated on the SCORE range. The PMRF dataset contains a large number of humpback vocalizations, providing a challenging environment for estimating both cue rates and animal densities. Previous efforts resulted in ambiguous animal locations, and localization efforts were abandoned. However, new techniques using methods partially described in Helble et al., 2012 have allowed for unambiguous animal locations, even during periods of multiple calling animals (see INITIAL RESULTS). The PMRF dataset also provides opportunities to calculate animal densities from other mysticetes, including fin and sei (Balaenoptera borealis) whales.

Data from a large U.S. Navy exercise conducted in 1999 have been obtained and processed by the Marine Physical Lab. These data, collected by 16 large physical aperture, well-filled arrays deployed in the sea trial, provide the ability to obtain high spatial resolution positioning estimates of low and mid frequency calling animals during the months of March, April, and May in the southern California Bight. The dataset is known to contain many fin whale and blue whale calls, providing a unique opportunity to estimate the average cue rate of these species using adaptive beamforming/localization techniques. We propose to use this dataset to estimate cue rates of fin and blue whale calls during this time period, and also compute animal density estimates. The density estimates of fin whales can be quantitatively compared to those derived from line transect studies in the same region (Barlow, 1995, Forney et al., 1995). These results also will provide the opportunity to investigate methods for "fusing" together the animal densities from visual and acoustic techniques in order to decrease the

overall uncertainties of the estimates, as well as to estimate the percentage of non-vocalizing animals in the population.

Estimating cue rates for minke whales (Balaenoptera acutorostrata) was originally proposed in the white paper of this proposal, but we have subsequently decided to focus on endangered species of baleen whales, because there has been considerable effort in estimating minke whale densities from acoustic cues in the habitat surrounding the PMRF range (Marques et al., 2012; Martin et al., 2013), and there is an ongoing effort for establishing cue rates on the PMRF range. Its worth noting that an established cue rate was a hindrance to estimating animal density in Martin et al., 2013, because at the time the paper was written only a single animal had been tracked on the range. The goal of the proposed research is to establish cue rates using large sample sizes in order to mitigate these shortcomings in calculating animal density.

The work in this project was leveraged with other ongoing programs, listed in Related Projects below.

WORK COMPLETED

The initial funding for this project arrived in house late April, 2014. Since then algorithms have been developed in order to automatically associate individual units from localized humpback whales on the PMRF range. Fours years of data has been amassed with calling statistics on nearly one hundred individual humpbacks, providing insight on cue rate in relation to behavior, seasonality, and exposure to noise, among other variables. This data is currently being analyzed for in preparation for publication to JASA or other appropriate peer reviewed journal.

RESULTS

The efforts in this program are a continuation and extension of the work performed in previous projects. Most of the results from those efforts appear in Helble et al., 2012; 2013a; 2013b. A new manuscript outlining the technical details of humpback call association was accepted for publication by JASA in November 2014. This manuscript is titled “Automated acoustic localization and call association for humpback whales on the Navy’s Pacific Missile Range Facility”, Helble et al. J. Acoust. Soc. Am., Nov, 2014, 11 pgs plus 9 figs.

IMPACT/APPLICATIONS

Passive underwater acoustic monitoring of marine mammal sounds is the Navy’s primary method for characterizing the presence, distribution, and number of marine mammal species in a wide variety of environments, particularly those associated with Navy training ranges. Marine mammal population density estimates are particularly important in regions of Navy activities, or potential activities, in order to properly evaluate their potential impact under federal environmental legislation. Understanding, and improving, this passive acoustic monitoring capability will decrease the environmental risk of Navy training exercises and other activities. Both the southern California Bight region and the area west of Kauai are areas of operational/training interest to the Navy. In addition, since these research efforts involve a student in the field of marine bioacoustics, as part of their thesis research, this project will help provide the Navy with the future generation of highly trained ocean bioacousticians aware of both Navy needs and environmental issues.

RELATED PROJECTS

The efforts in this project will be heavily leveraged with other programs. First, efforts in our Living Marine Resources project titled "Improving the Navy's Automated Methods for Passive Underwater Acoustic Monitoring of Marine Mammals" are focused on modifying the GPL processor for detecting a wide variety of marine mammal calls recorded by Navy range monitoring systems (the range hydrophones at the SCORE and PMRF ranges, and John Hildbrand's HARP packages in southern California), and environmentally calibrating the resulting detected call counts in the HARP data. Results from Gerald D'Spain's ONR Code 322-MMB project "Improving the Navy's Passive Underwater Acoustic Monitoring of Marine Mammal Populations" will be used to improve environmentally calibrated call density estimates. Steve Martin's ongoing project with PAC FLEET has supplied archival data from the PMRF Range hydrophones and will be helping, in coordination with Dave Moretti at NUWC, with data collection from the SCORE Range hydrophones. Finally, algorithms developed in the "Glider-Based Passive Acoustic Monitoring Techniques in the Southern California Region", Code 322-MMB, including the GPL detector, are being used in this program to automatically scan the data for marine mammal calls of interest.

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